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Applications of HCMM Satellite Data to the Study of Urban Heating Patterns

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HCM-001

I. Background (Summary of Work To Date)

In preparation for the HCMM launch a diverse analysis system has been developed for application to various types of satellite data. Its capabilities include variable smoothing, character mapping, contouring, subsetting, and geographical location (Figure 1).

The system has been implemented in order to analyze effects of urbanization on surface temperature and albedo patterns. To test the system both day and night Very High Resolution Radiometer (VHRR) data for NOAA-3 and NOAA-5 satellites were used to study the Los Angeles area under clear atmospheric conditions. A correction for absorption by water vapor in the infrared was applied to give the temperature deficit between the measured and actual surface temperatures as a function of integrated water vapor.

The surface of the Los Angeles basin has been greatly influenced by man (Figure 2). Construction of buildings and other structures or surfaces inhibit evaporation and also serve as strong conducting media for the retention of heat. The built up area, because of increased roughness, shadowing, and high thermal inertia shows daytime surface temperatures that are somewhat lower than those of the flat industrial regions. But after sunset, because of high heat storage during the day, the built up inner city area reveals a maximum in surface temperature-reflecting the urban heat island. Flat unpopulated areas, on the other hand, whose thermal inertia is much lower than that of the city, gain and lose heat at a more rapid rate, consequently, a higher diurnal temperature

variation results. Vegetated regions, where higher moisture content inhibits a large partition between sensible and stored heat, exhibit small temperature variations. This effect is illustrated quite well in the wooded regions of the Santa Monica Mountains. Just after sunset or when the sun's elevation is low, slope characteristics of the terrain there tend to briefly override other determinants of surface temperature, causing anomalies of two to four degrees celcius to occur on the southern slopes. Surface albedo was found to be of lesser importance in the determination of surface temperature.

It has been shown that satellites can be efficiently used to map small scale thermal and reflective patterns in a consistent timely manner. In the future, diurnal surface temperature differences derived from Heat Capacity Mapping Mission (HCMM) satellite data will be input to a boundary layer model to produce values of the soil's physical properties, such as thermal inertia and moisture availability, which are responsible for the formation of the urban heat island.

II. Current and Future Objectives

A. General

High resolution satellite data are to be utilized to test heat flux calculations and to explore the character of the urban heat island in general. Inversion methods are being tested which will yield values of the substrate parameters, given the observed surface temperature distribution determined from satellite measurements. An elaborate system for processing and analyzing quantitative satellite

data for any given region and for any spacecraft instrument has been developed on the Penn State 370/168 computer. The capabilities of this system are probably unique for any university.

B. Specific Program for Coming Quarter

1. Refine heat flux model so that it can predict as accurately as possible, given the measurable meteorological and solar variables, the daily march of temperature at the soil-air interface.
2. Test numerical inversion scheme to determine if substrate parameters can be retrieved from the heat flux equations for a set of observed ground temperatures.
3. Complete development on the satellite data analysis system, and begin analysis of high resolution thermal and visible (ground albedo) measurements over urban regional scale. Regional areas included for analysis will be Los Angeles (currently being studied), St. Louis, Houston, and Washington, D. C.
4. Use satellite data to determine substrate parameters via inversion methods (see 2b) and surface albedo using radiative transfer equations.

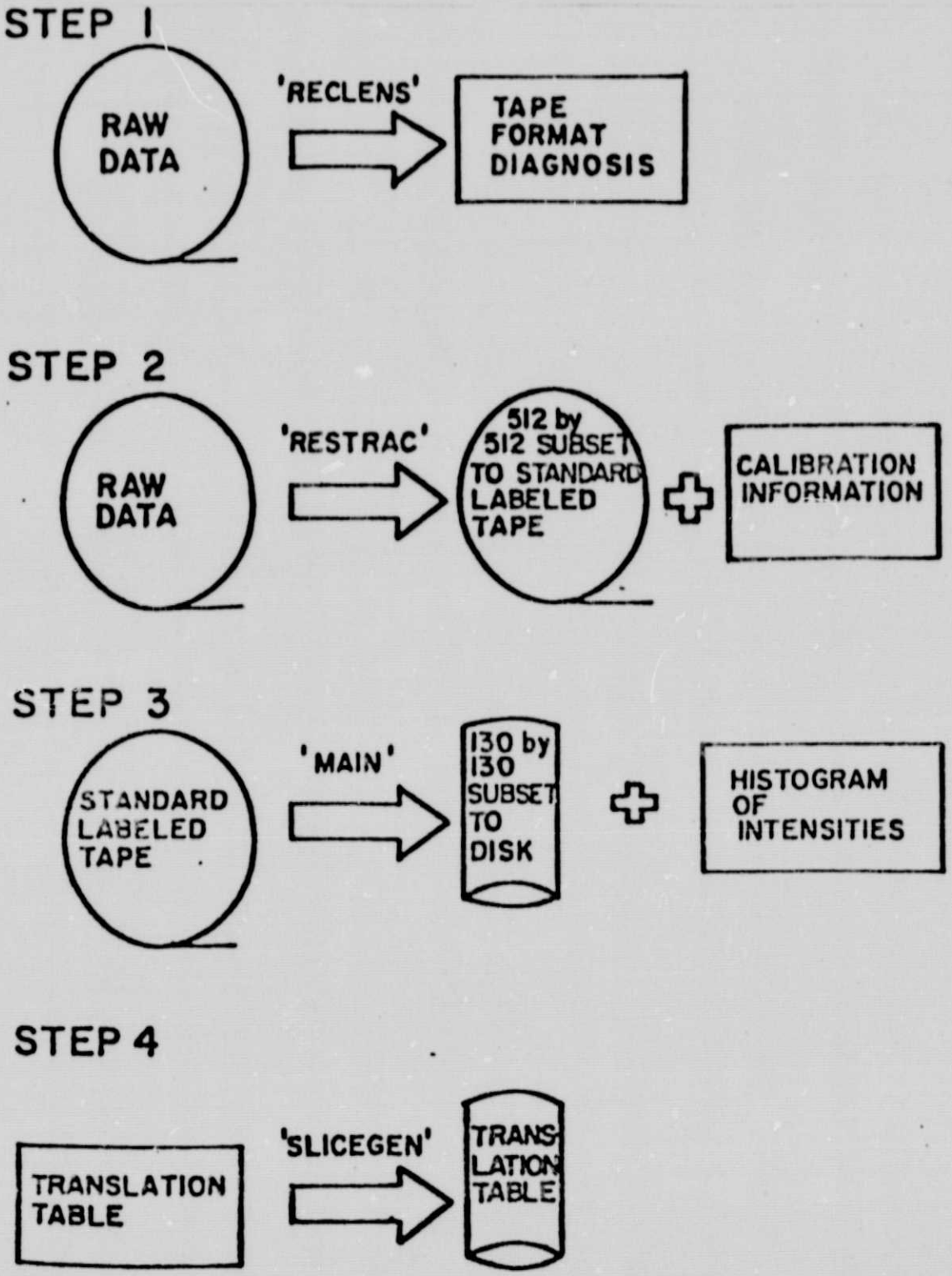

Figure 1. Schematic Diagram of the Data Processing Procedure.

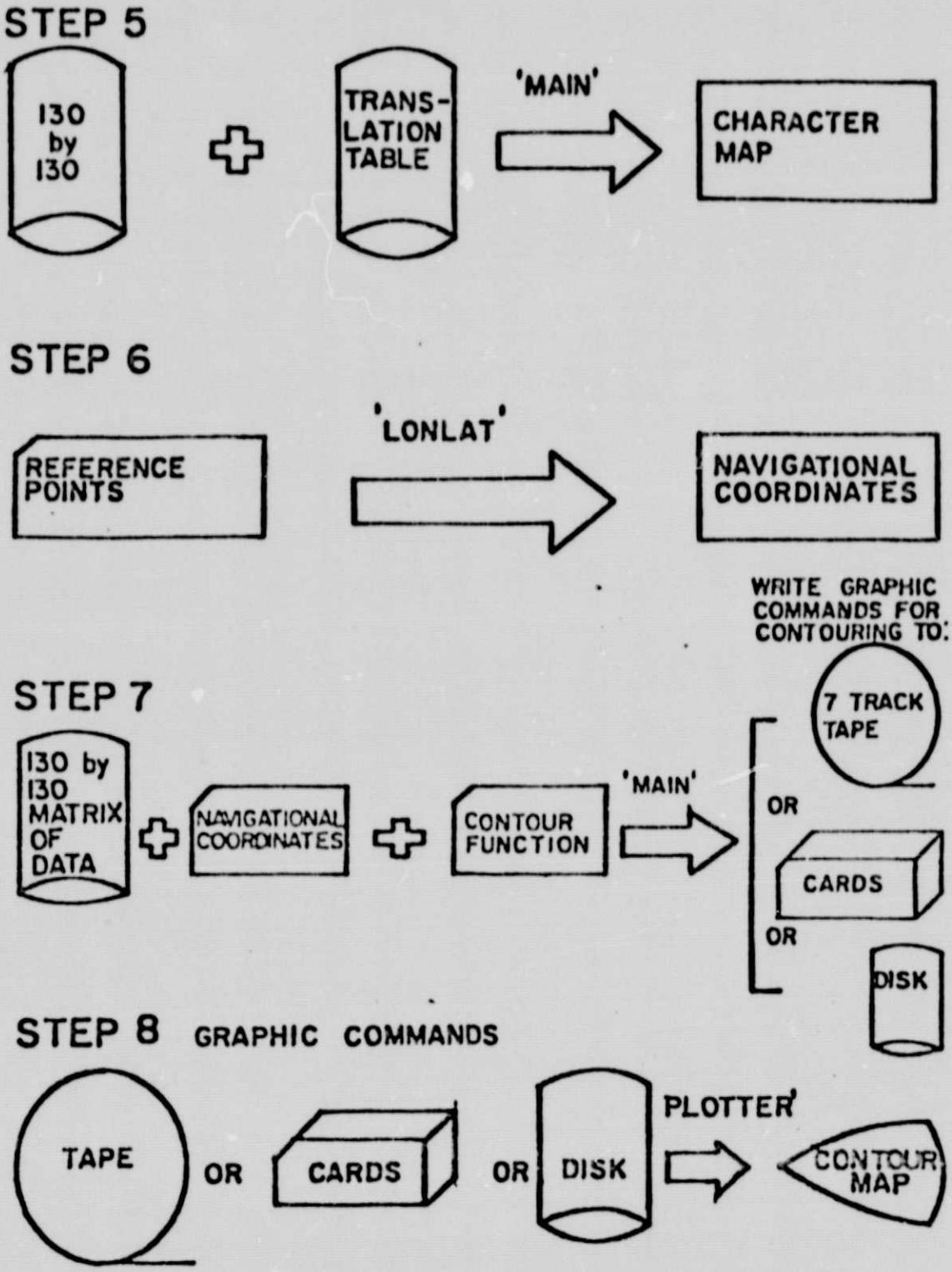

Figure 1. (cont.)

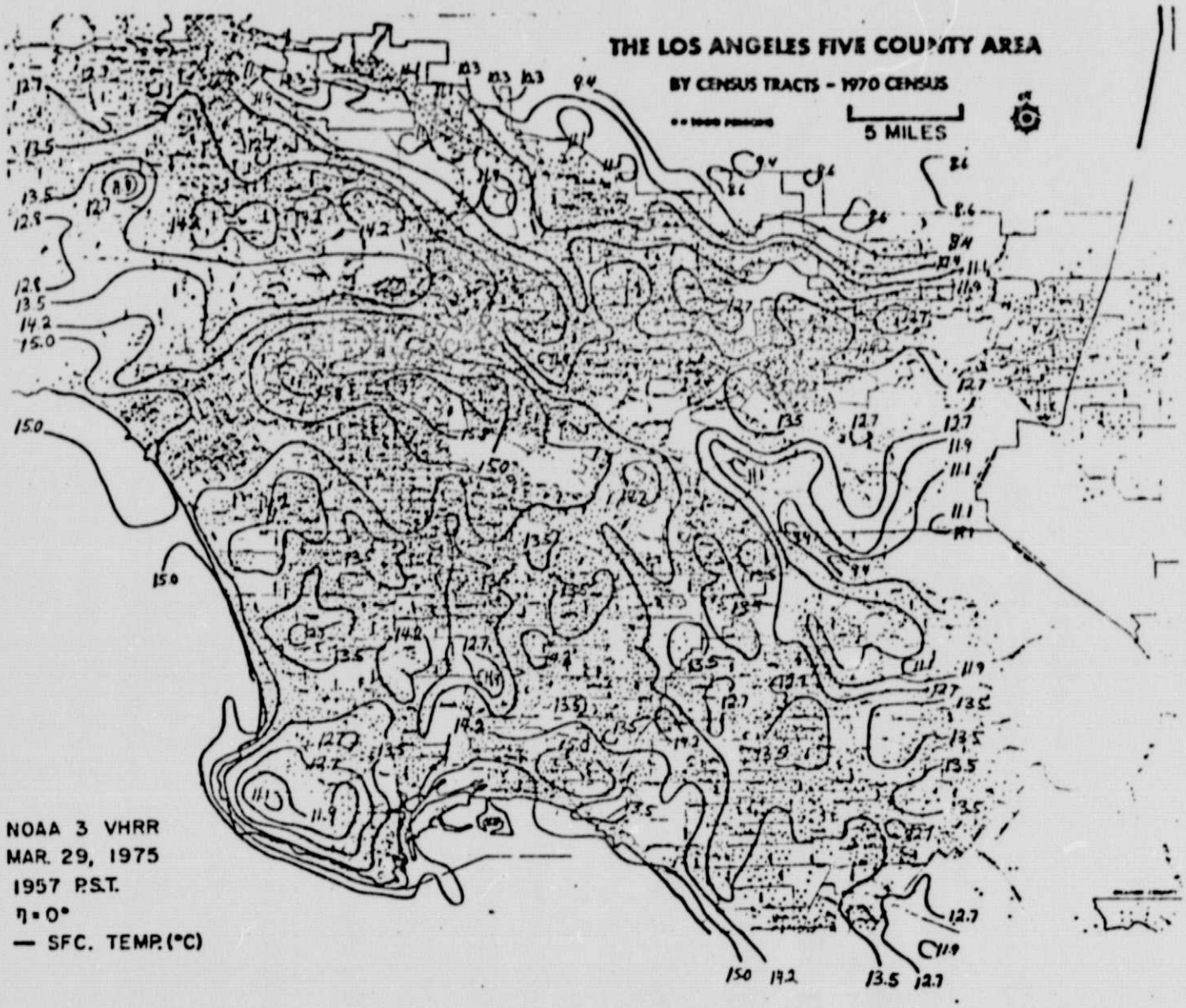

Figure 2: NOAA-3 VHRR Temperature Analysis for Los Angeles March 29, 1975, 1957 local time. Satellite nader angle was 0°.